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RESEARCH ARTICLE

Performance, Egg Qualities, and Blood Parameters of Layers Fed Diets Containing Graded Levels of Sundried Sweet Orange Fruit Peel Meal

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ABSTRACT

A 10-week feeding trial was conducted to determine the performance, egg qualities, and hematology of layers fed diets containing sun-dried sweet orange peel meal (SOPM). A total of 140 Isa brown point of lay birds, aged 20 weeks were used for the experiment. SOPM was incorporated to replace 0, 10, 20, 30, and 40% maize. The birds were randomly assigned to the diets in a Completely Randomized Design; each diet group had 28 birds and 4 replicates with each replicate having 7 birds. Observed results showed that SOPM did not significantly (NS) (p>0.05) affect final weight and egg number. However, weight change, feed intake, feed conversion ratio, mortality, cost of 1 kg feed, and cost of feed consumed were significantly different ($P < 0.05$) among treatments. Egg weight and egg length were significantly ($P < 0.05$) different, which ranged from 56.18 to 58.73 g and 3.74–4.17 cm, respectively. Shell thickness and egg width were NS ($P > 0.05$) influenced, and ranged from 0.80 to 0.84 and 2.63–2.71 cm, respectively**.** Internal egg parameters, i.e., yolk width, yolk height, albumin weight, albumin length, and yolk index were significantly ($P < 0.05$) affected. Hematological profile (packed cell volume, hemoglobin, white blood cell, red blood cell, mean corpuscular volume, mean corpuscular hemoglobin (MCH), MCH concentration, lymphocyte, and neutrophil) of birds showed significant differences ($P < 0.05$). The study revealed that SOPM did not have an adverse effect on the performance of layers even at 40% replacement of maize while in lay. Its inclusion decreased the cost of feed linearly, did not compromise external and internal qualities of eggs or the health of the birds.

Key words: Hematology, performance, point of lay, serum

INTRODUCTION

The need to provide feed is basic to any livestock enterprise including poultry. However, making the feed cheaply available is more compelling to profitability and sustainable livestock development.[1] One approach to feed cost reduction is the use of cheaper sources of nutrients. The energy and protein components of a feed are usually high in cost, and a reduction in the cost of the energy and protein sources could translate to reduced cost of feeding livestock.[1]

Some of the major conventional sources of energy and protein in monogastric animal feeding are also the bulk of raw materials for the brewery and flour milling industries, apart from being sources of food for human consumption.[2,3] Their competitive demand has resulted in scarcity and high cost; thereby, raising the prices of animal products beyond the reach of the average populace. As a result of this, research efforts have been directed toward the increased use of agro-industrial by-products (AIBP) and farm residues as alternative feed resources.[4] These are cheaper and less competitive sources of livestock feed, and some have been reported to play an important role in the maintenance of normal structure and function of intestinal mucosa because of the high fiber content of most of these products.[5] Some AIBP such as maize offal,[6] cocoa husk meal,[7] cassava root meal/brewery yeast slurry,[8] and citrus peel[9,10] have been used to replace cereal grains in poultry diets.

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Sweet orange (*Citrus sinensis*) by-products such as peels and pulps are abundant in Nigeria especially in the dry season which is the main harvest period.[11] The authors reported that heaps of the peels of sweet orange are usually noticed on streets and along major roads in Nigeria because Government and orange retailers have no strategic program for its disposal thus becoming an environmental problem. Sweet orange rind is comparable in energy and protein to maize.[9,10] Studies are still in progress to elucidate the usefulness and profitability of citrus peel, which is not subject to pest attacks, as an animal feed ingredient. Available reports include studies by Jong-Kyu *et al.,*[12] Oluremi *et al.,*[9] Hon *et al.,*[13] Agu *et al.,*[14] Ojabo *et al.,*[15] and Ojabo *et al.*[16]

Objectives of the study

The objectives of this study were as follows:
To determine the performance of layers fed diets containing graded levels of sun-dried sweet orange fruit peel meal.
To determine the cost implication of including sweet orange fruit peel meal in the diet of layers.
To determine the hematological profile of layers fed sweet orange (*C. sinensis*) fruit peel meal based diets.
To determine the external egg quality parameters of layers fed with sweet orange peel meal (SOPM) based diets.
Evaluate the internal egg qualities of eggs from chicken fed sweet orange fruit peel meal based diets.

MATERIALS AND METHODS

Experimental location

The feeding trial was carried out at the Poultry Unit of the Livestock Teaching and Research Farm, Department of Animal Production, Kogi State University, Anyigba, which lies between Latitude 7°15' and 7° 29'N of the equator and Longitudes 7° 11[1] and 7° 32[1] East of the Greenwich Meridian.[17]

Experimental birds and management

A total of 140 Isa Brown Point of lay birds, aged 20 weeks were used for the experiment. The birds were administered anti-stress on the day of arrival and equally administered coccidiostat before being assigned to the different diets. Sun-dried sweet orange peel was incorporated to replace maize at 0, 10, 20, 30, and 40% [Table 1]. The birds were transferred to California type cage at 21 weeks of age and allowed an adjustment period of 1 week before the commencement of data collection. The birds were randomly assigned to the five experimental diets in a Completely Randomized Design. Each diet group had 28 birds and four replicates with each replicate having 7 birds. The proximate composition of each experimental diet was analyzed as described by AOAC.[18]

Performance parameters

The initial weight of birds was determined by weighing them per replicate at the beginning of the experiment and the end. Daily feed intake was determined by subtracting the leftover from the quantity of feed offered. Furthermore, feed conversion ratio was determined by calculating the quantity of feed required to produce a dozen of the egg.

Determination of the economics of feeding dry Sopm based diets to layers

The economics of feeding sun-dried SOPM based diets to laying birds was estimated using the prevailing market prices of the feedstuffs. Using the following formulae;
Cost of producing 100 kg of each feed was estimated and then used to compute consumed feed cost/bird and cost of 1 kg of feed.

i. Cost of 1 kg feed (₦)
ii. Cost of feed consumed/bird (₦)
iii. $$\text{Percentage Mortality }(\%) = \frac{\text{No of dead birds}}{\text{No of birds at the beginning of the experiment}} \times 100$$

External egg quality parameters

Egg weight was taken with the aid of electronic digital weighing balance. This was done after the egg has been cleaned with tissue paper to remove any fecal material or litter.[10] Two crack-free eggs per replicate and eight eggs per treatment were randomly sampled when the birds were 24, 25, 26, 27, and 28 weeks old for external egg quality determination. Egg shape index was determined as the ratio of maximum breadth and length.[19] Shell thickness was determined by breaking open the egg and emptying its content. The shell was then washed under flowing water to remove albumen remains, after which the shell thickness was measured using micrometer screw gauge. Egg length was measured using Vernier calipers.[10]

The internal egg quality parameters determined include egg yolk width, egg yolk weight, yolk height, albumen weight, albumen height, and egg yolk index. Two crack-free eggs per replicate were randomly sampled when the birds were 24, 25, 26, 27, and 28 weeks old for internal egg quality determination. All eggs sampled for egg quality determination were collected on the same day and before 12 noon. The eggs were carefully cleaned with tissue paper to remove fecal or litter materials before weighing. Egg quality determination was carried out within 12 h of egg collection. Each egg after weighing was broken at the equatorial region, and the content gently poured into a flat plate for internal egg quality determination. Egg yolk diameter was measured in centimeters (cm) with Vernier calipers, as the widest circumference of the yolk, while yolk height (cm) was measured from the highest point of the yolk to the base on the flat plate, with the aid of Vernier calipers. Yolk index was computed by dividing yolk height by yolk diameter. Albumen height was taken with the aid of Vernier calipers as the highest point just close to the edge of the yolk to the base on the flat plate.

Hematological parameters

At the end of the feeding trial which lasted 10 weeks, one bird per replicate was randomly chosen for blood collection. The blood samples of birds were collected into a labeled sample bottles treated with ethylenediaminetetraacetic acid (anti-coagulant) through the wing vein using new sterilized disposable needle and syringe. The following hematological parameters were determined as described by[20] Schalm *et al.* (1975); packed cell volume (PCV), red blood cell (RBC), hemoglobin (Hb), white blood cell (WBC), mean corpuscular hemoglobin (MCH), heterophils (Het.), MCH concentration (MCHC), eosinophils, lymphocyte (LYMP), and mean corpuscular volume (MCV).

Statistical analysis

Data were collected, processed and analyzed using computer software package SPSS version 20. Means were separated using the same package where found to be significantly different at 5%.

RESULTS

Results of the effect of SOPM on performance characteristics of laying birds are presented in Table 2. Final weight was not significantly (NS) ($P > 0.05$) affected by the treatments, however weight change, feed intake, feed conversion ratio,

Table 1: Composition of experimental diets (%)

Ingredients	SOPM (0%)	SOPM (10%)	SOPM (20%)	SOPM (30%)	SOPM (40%)
Maize	45.00	40.50	36.00	31.50	27.00
FFSBM[2]	30.00	30.00	30.00	30.00	30.00
SOPM[1]	0.00	4.50	9.00	13.50	18.00
Maize offal	15.25	15.25	15.25	15.25	15.25
Bone meal	4.00	4.00	4.00	4.00	4.00
Limestone	5.00	5.00	5.00	5.00	5.00
Methionine	0.25	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated nutrients/energy					
Crude protein (%)	17.22	17.15	17.08	17.02	16.95
Crude fiber (%)	4.32	4.80	5.29	5.77	6.26
Ether extract (%)	7.46	7.60	7.75	7.89	6.26
Calcium (%)	3.42	3.43	3.44	3.45	3.46
Total phosphorus (%)	0.96	0.98	0.99	1.01	1.02
Ash (%)	2.09	2.40	2.71	3.02	3.33
Energy (Kcal/KgME)	2930.90	2942.81	2952.72	2963.63	2974.50

[1]SOPM: Sweet orange peel meal, [2]FFSBM: Full fat soybean meal

mortality, cost of 1 kg feed, and cost of feed consumed were significantly different ($P < 0.05$) among treatments.

The external egg quality of the experimental birds shown in Table 3, egg weight and egg length were significantly ($P < 0.05$) different across the treatments, which ranged from 56.18 to 58.73 g–3.74 to 4.17 cm, respectively. There was no definite pattern of variation for the parameters. Shell thickness and egg width were NS ($P > 0.05$) influenced by the treatments. Observed values ranged from 0.80 to 0.84–2.63 to 2.71 cm, respectively.

The internal egg characteristics of layers are shown in Table 4. All parameters measured, i.e., yolk width, yolk height, albumin weight, Albumin length, and yolk index were significantly ($P < 0.05$) affected by the treatments.

The hematological profile of the experimental birds is shown in Table 5. The results of hematological profile of laying birds fed varying levels of SOPM showed significant differences ($P < 0.05$) in all hematological parameters, i.e., PCV, Hb, WBC, RBC, MCV, MCH, MCHC, LYMP, and neutrophil.

DISCUSSION

Observed results show that feed intake, which varied from 131.88 g to 144.11 g/day, may indicate that substitution of maize by SOPM in the diets did not affect the appetite of birds as all the diets were equally palatable and acceptability to the birds. Feed intake, though significantly ($P < 0.05$) different among the treatments was adequate. This observed value range is comparable with 128–148 g observed by Iheukwumere *et al.*[21] but higher than 103.97–110.49 g reported by Oyewole *et al.*[22] for Nera black layers fed 48 h fermented SOPM based diets. This is an indication that SOPM inclusion did not affect the palatability of the diets adversely. Substitution of maize did not

Table 2: Effect of sun-dried SOPM on performance and production of laying birds

Parameter	0%	10%	SOPM 20%	30%	40%	SEM	LOS
Initial weight (g)	1.43	1.42	1.42	1.41	1.45	0.21	NS
Final weight (g)	1.36	1.46	1.48	1.43	1.52	0.02	NS
Weight change (g)	−67.50^{e}	40.00^{c}	60.00^{b}	17.50^{d}	92.50^{a}	28.45	*
Feed intake (g)	132.90^{d}	131.88^{d}	137.28^{c}	144.11^{a}	140.23^{b}	1.52	*
Egg number/bird	33.31	33.30	33.32	33.56	33.31	0.15	NS
FCR (%)	3.99^{b}	3.96^{a}	4.12^{c}	4.32^{e}	4.21^{d}	0.31	*
Mortality (%)	3.57^{b}	3.57^{b}	7.15^{a}	3.57^{b}	0.00^{c}	1.42	*
Cost of 1 Kg feed (₦)	186.12^{a}	179.77^{b}	173.93^{c}	168.57^{d}	163.61^{e}	1.83	*
Cost of feed consumed (₦)	1385.15^{a}	1321.61^{d}	1337.09^{c}	1360.37^{b}	1284.76^{e}	13.43	*

^{abcde}Means on the same row with different superscripts are significantly different ($P < 0.05$). NS: Not significant ($P > 0.05$), SEM: Standard error of mean, SOPM: Sweet orange peel meal, LOS: Level of significance, FCR: Feed conversion ratio

Table 3: External egg quality of layers fed SOPM

Parameter	0%	10%	SOPM 20%	30%	40%	SEM	LOS
Egg weight (g)	56.18^{d}	58.53^{a}	57.63^{b}	58.73^{a}	57.35^{c}	0.58	*
Egg length (cm)	4.15^{a}	4.17^{a}	4.01^{a}	3.74^{b}	4.04^{a}	0.08	*
Shell thickness (mm)	0.80	0.80	0.80	0.84	0.80	0.03	NS
Egg width (cm)	2.67	2.63	2.70	2.71	2.71	0.02	NS

LOS: Level of significant, NS: Not significant ($P > 0.05$), *Values with different superscripts are significantly different $P < 0.05$, SEM: Standard error of mean, SOPM: Sweet orange peel meal

Table 4: Internal egg quality of layers fed SOPM

Parameter	0%	10%	SOPM 20%	30%	40%	SEM	LOS
Yolk width (cm)	2.41^{b}	2.38^{b}	2.41^{b}	2.32^{b}	2.59^{a}	0.05	*
Yolk weight (g)	12.95^{e}	13.20^{c}	13.10^{d}	14.23^{b}	14.75^{a}	0.30	*
Yolk height (cm)	1.11^{c}	1.23^{b}	1.35^{a}	1.30^{a}	1.20^{b}	0.03	*
Albumin weight (g)	30.10^{e}	33.88^{b}	31.95^{d}	36.98^{a}	32.55^{c}	0.91	*
Albumin length (cm)	5.80^{c}	5.45^{e}	6.15^{a}	5.98^{b}	5.75^{d}	0.09	*
Yolk index (%)	51.53^{d}	51.71^{c}	56.16^{a}	55.73^{b}	46.62^{e}	1.74	*

^{abcde}Means on the same row with different superscripts are significantly different ($P < 0.05$). SEM: Standard error of mean, LOS: Level of significance, SOPM: Sweet orange peel meal

Table 5: Hematological profile of layers fed varying levels of sun-dried SOPM

Parameter	0%	10%	SOPM 20%	30%	40%	SEM	LOS
PCV (%)	34.25a	30.75d	32.00c	32.25b	32.25b	0.49	*
Hb (g/dl)	11.38a	10.10d	10.60b	10.30c	10.68b	0.24	*
WBC (10^9/ml)	217.45b	210.58d	229.58a	213.98c	205.30e	3.57	*
RBC (10^{12}/ml)	2.36a	2.36a	2.55a	2.16b	2.49a	0.05	*
MCV (f/l)	137.33b	137.80a	135.83c	135.63c	138.00a	0.62	*
MCH (pg)	42.80c	42.65c	43.90a	43.38b	42.45c	0.51	*
MCHC (%)	32.38c	33.20a	31.80d	31.13e	32.85b	0.34	*
LYMP (%)	97.00c	97.25b	96.25d	97.75a	95.75e	0.29	*
Neutrophil (%)	3.00d	3.25	3.75b	2.25e	4.25a	0.32	*

abcdeMeans on the same row with different superscripts are significantly different ($P < 0.05$). NS: Not significant ($P > 0.05$), LOS: Level of significance, SEM: Standard error of mean, PCV: Packed cell volume, RBC: Red blood cell, MCV: Mean corpuscular value, MCH: Mean corpuscular hemoglobin, Hb: Hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, LYMP: Lymphocyte, SOPM: Sweet orange peel meal

affect final weight gain significantly ($P > 0.05$), which might indicate that the birds utilized the diets optimally.[23] All the weight of the birds on the various treatment falls within 1289–1571 g reported by Tuleun *et al.*[24] but higher than 1237.74 g reported by Ojedapo *et al.*[25] for 20 weeks old Nera black pullets. Final weight of birds ranged from 1.36 kg (0% SOPM) to 1.52 kg (40% SOPM), with no clear pattern of variation. Weight change also varied from −67.50 g (0% SOPM) to 92.50 g (40% SOPM) with no definite pattern of variation. Observed final weight values indicate that all birds on SOPM based diets increased in weight during production except those on the control diet. The stress and level of lay may have resulted in loss of weight for the birds on 0% SOPM, because they laid more eggs. Mortality was recorded in all treatments except for treatment 5, which suggest that SOPM is not-toxic to laying birds. This is because no bird died at 40% SOPM inclusion. SOPM resulted in significant ($P < 0.05$) reductions in feed cost per kg and cost of feed consumed per bird. This could be because the SOPM used was obtained at lower cost relative to maize. Feed cost/kg gain of birds on SOPM based diets is comparable to the control. However, the highest cost was recorded with birds on diet 0% SOPM. Cost of production of laying birds declined significantly ($P < 0.05$) as percent substitution level of maize increased. Thus, indicating that maize substitution by SOPM in laying bird diets is capable of reducing cost of production. This is because dietary SOPM was cheaper compared with maize. Consequently, the cost of the SOPM-based diets was lower than the control's.

Average egg weight range of 56.18–58.73 g obtained in this study is lower than 59.50–64.50 g for European commercial strains and 63 g for Olympic black layers in Akure, Nigeria,[26] and 59.47–62.87 g by Oyewole *et al.*[10] for Nera black layers on fermented SOPM based diets. The characteristically smaller eggs observed in this study might be due to differences in feed composition, strain of birds, and age of birds. The shell thickness recorded for all treatments is adequate to prevent the shell from crack during handling. The minimum recommended shell thickness for chicken egg is 0.33 mm.[27] Thick egg shells are preferred because they encourage the best use of the nutrients contained in the egg by the embryo, enables the eggs to pass through the market handling without breakage, there is less chance for the egg to become dehydrated and less chance of bacteria penetrating inside the egg and they offer the best protection from mechanical damage.[28] Hence, SOPM did not adversely affect shell quality of the egg. The birds were able to mobilize calcium and phosphorus for eggshell formation even in SOPM based diets.

Average yolk width observed ranged from 2.32 cm to 2.59 cm. It was higher in the SOPM groups. Yolk weight obtained ranged from 12.95 g to 14.75 g, which was within the range of 12.31–17.91 g reported by Madubuike and Obidimma.[29] The control birds had the least value. The observed yolk height values fell between 1.11 cm and 1.35 cm. These values were lower than the values of 1.46–1.56 cm.[29] Albumin length of 5.45–6.15 cm was observed. Albumin length and yolk height are both indicators of the freshness and quality of an egg.[29] The yolk index is a measure of the standing-up quality of the yolk, observed values ranged from 46.62% to 56.16%. Card and Neshiem[30] had reported 33% and 50% for yolk indices of fresh eggs. Ezieshi *et al.*[31] and Garba *et al.*[32] had observed 42–45% and 44–47%, respectively. Observed values of internal egg quality parameters seem to indicate that incorporation of SOPM in layer diet did not compromise the internal quality of egg. The observed values for albumin weight ranged from 30.10 g to 36.98 g were higher than 26.66 g observed by Madubuike and Obidimma.[29]

The PCV value range of 30.75–34.25% obtained in the study is within the range of 24.9–45.5% reported by Mitruka and Rawnsley[33] for healthy birds. This indicates that the birds were not ill. Hb values obtained in the study were significantly higher in 0% SOPM (11.38 g/dl) than other dietary groups. Observed Hb values of 10.10–11.38 g/dl are normal and within the range of 7.40–13.10 g/dl for healthy birds.[33] This indicates that inclusion of SOPM in the diets was not detrimental to the formation of Hb and hematopoiesis. WBC values obtained in this study were significantly higher in 20% SOPM (229.58) than in other dietary groups. This trend does not indicate any adverse effect of SOPM on the immune system of the birds. Observed RBC values range of 2.16–2.55 (10^{12}/l) is <3.7–7.5 reported by Jain.[34] However, the observed value of 30% only is different from that of the control while others are similar. Thus, this indicates that SOPM promoted hematopoiesis, having furnished the birds with minerals and vitamins required for blood synthesis.

The MCV, MCH, and MCHC value ranges obtained in the study were 135.63–138.00 f/l, 42.45–43.90 pg, and 31.13–33.20% were comparable to the ranges 104–135 f/l, 32–43.9 pg, and 30.2–36.2 g/l for MCV, MCH, and MCHC, respectively, reported by Jain.[34] This indicates that the birds were healthy and were not anemic. Neutrophil values obtained in the study were significantly different (2.25–4.25%) as they were influenced by the treatment but were within the range of 0.5–7.6% reported by Jain.[34] The observed LYMP values were significantly different among the treatments with 30% SOPM recording 97.75 which was highest. These observed parameters which disagreed with the works of some researchers might be due to genetic, age, breed, nutrition, and geographical location of the birds aside from the laboratory precision used for evaluation.

CONCLUSION

The study revealed that layers fed SOPM performed optimally even at 40% replacement of maize while in lay. Inclusion of SOPM decreased the cost of feed linearly. The external and internal qualities were not compromised even at 40% replacement of dietary maize. More so, evaluated hematological parameters indicate that SOPM is not toxic and is capable of promoting good health when fed to birds.

RECOMMENDATIONS

It is recommended that farmers can replace 40% of dietary maize with sweet orange fruit meal to achieve a reduction in feed cost with increased profitability while maintaining good external and internal egg quality characteristics.

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